

PATENT SPECIFICATION

DRAWINGS ATTACHED

L113.850

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Date of Application and filing Complete Specification: 23 March, 1967.

No. 13674/67.

Application made in United States of America (No. 538686) on 30 March, 1966.

Complete Specification Published: 15 May, 1968.

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Index at acceptance: —H2 A(2E5, 2E7, 2E10); F1 C(D2C, D4A1)

Int. Cl.: —H 02 k 9/04

COMPLETE SPECIFICATION

Cooling Configuration for Fans

We, ROTRON MANUFACTURING CO., INC., a corporation organised and existing under the laws of the State of New York, United States of America, of Hasbrouck Lane, Woodstock, New York, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to a fan construction that employs the air stream and pressure gradients established during normal operation of the fan to create separate air flows for cooling the fan driving motor, without the addition of extra air moving elements.

As is well known, as the load on an electric motor increases, the power dissipated similarly increases. The resultant heating of the windings, if allowed to continue unchecked, can significantly shorten the motor life. In the case of some types of air moving devices or fans, an increase in outlet pressure, such as resulting from impediments in the main air stream, loads the driving motor and causes increased power dissipation. It is desirable, from an efficiency and reliability standpoint, that means be provided to remove excess heat from the motor and preferably that this cooling ability vary with the load so that a proper operational temperature can be maintained at all times.

Many prior art fans are designed such that the motor load decreases with increasing outlet pressure. In those cases, with the motor located in the main air stream created by the air moving element, e.g., a propeller, adequate cooling is available despite the decreased flow associated with increased outlet pressure due to the reduction in motor power. One other widely used fan configuration, however, poses problems which are not so readily soluble. In particular, those fans wherein the blade elements radially extend from a rotating

hub surrounding all or part of the motor, thereby maintaining the axial length of the fan at a minimum, inherently keep the motor out of the main air stream or expose it to but a small fraction of it, and accordingly cannot rely on the main air stream for cooling purposes. Furthermore, if the fan characteristics are such that motor load increases as the fan outlet is impeded, the problem becomes even more difficult.

In connection with the latter type of fan, it is known to establish an air flow path or paths across or through the motor structure itself by means of auxiliary impellers or blades which may either be driven by the motor itself or by an auxiliary motor of relatively low power. While these configurations offer advantages in large motors having ample room for additional air moving elements, they are in general inappropriate for smaller fans where space is at a premium and economy of manufacture a factor. Moreover, the added power required to drive the supplemental impeller can affect the efficiency of the overall fan to an extent which may not be permissible in a unit of limited size and power.

In accordance with the present invention, a self-cooled motor-driven fan comprises an electric motor enclosed in a housing, an air moving element driven by the motor to produce a main air stream axially of the motor, openings in the motor housing at each of its upstream and downstream ends, and means responsive to the main air stream to establish motor cooling air flows from each end of the fan through the openings at the two ends of the motor housing and back into the main air stream.

The invention thus provides a cooling arrangement for a fan motor which employs only the air stream and pressure gradients resulting from normal operation of the fan to establish the cooling air flows. Furthermore, the cooling capacity will vary automatically

with the load on the fan, thereby providing a more effective cooling action. Each end of the motor is separately cooled and thereby achieves more efficient cooling, without additional air moving elements.

5 Preferably, the housing includes a cylindrical portion and a pair of end faces, and the openings are provided in both of the end faces and in the cylindrical portion at circumferentially spaced places adjacent to each of the end faces, whereby the cooling air may flow in through the openings in the end faces and out of the circumferential openings in the cylindrical portion.

15 One end of the motor housing may be secured in a cup-shaped support which includes a base portion spaced from the adjacent end face of the housing and provided with at least one aperture to permit air flow to the openings in the end face, and an axially extending wall portion surrounding a part of the cylindrical portion of the housing adjacent to the said one end, the wall portion being radially spaced from the cylindrical portion opposite the circumferential openings therein adjacent to the said one end, to provide an annular gap surrounding the circumferential openings to enable air flow from the openings into the main air stream. The motor may then include a shaft extending through the end face at the other end of the housing and the air moving element comprises a plurality of blades mounted on a hub having both an end wall adapted to be secured to the shaft and spaced from the associated end face of the housing, and an axially extending side wall surrounding a part of the cylindrical portion of the housing and extending beyond the circumferential openings therein adjacent to the said other end, the side wall being radially spaced from the cylindrical portion of the housing over the full axial extent of the side wall.

45 These arrangements create an air flow through the openings in the upstream end face of the motor housing and out of the adjacent circumferential openings in the cylindrical portion of the housing. At the same time, the main air stream pressure gradient established by the propeller blades creates an air flow through the motor housing in a direction opposite to the main flow. This cooling air enters the openings in the hub end wall, passes through the openings in the associated end face of the housing and then exits into the main air stream from the openings in the cylindrical portion of the housing.

50 Thus, two separate flows for cooling the motor are created, maintaining each end of the motor separately cool without creating a large pressure drop across the motor which would interfere with the overall performance of the fan. Since the pressure gradient across the fan blade increases as the load increases, the cooling flow correspondingly increases,

thereby automatically adjusting for changes in motor heating.

The entire fan structure may be mounted within a tubular duct or venturi supported by struts or a spider extending from the support at the upstream end of the fan.

One example of a fan constructed in accordance with the invention is illustrated in the accompanying drawings, in which:

Figure 1 is a side elevation with parts in cross-section showing the various air paths created, the cross-section being taken on the lines 1—1 in Figure 2;

Figure 2 is an end elevation looking from the upstream side and partially broken away to show the upstream end face of the motor housing; and,

Figure 3 is an end elevation of the downstream end of the fan configuration partially broken away to show the downstream end face of the motor housing.

A fan motor 10 includes a can-like outer housing 12 with a cylindrical portion 14 and a pair of end faces 16 and 18. As will become evident hereinafter, the end face 16 is at the upstream end of the fan while the end face 18 is at the downstream end.

The upstream end face 16 of the housing is provided with openings 16a (Figure 2) while the downstream end face 18 has similar openings 18a (Figure 3). The cylindrical portion of the housing 14 includes two sets of openings extending circumferentially around it. A first set, 14a, is situated adjacent the upstream end face 16, while the other set 14b is located adjacent the downstream end face 18.

The motor is held by a cup-shaped support 20, having a base portion 22 and a generally cylindrical wall 24, within which the upstream end of the motor housing is snugly received. A plurality of threaded lugs 26 are provided in the upstream end wall 16 and extend through appropriate openings in the base portion 22, where they receive nuts to hold the support fast to the motor housing.

The interior surface of the base 22 is spaced from the end face 16 of the motor housing over its entire surface, except where the lugs 26 pass through. Apertures 28 are provided in the base 22 to permit free flow of air from the surrounding atmosphere into the opening 16a in the upstream end face.

The interior surface of cylindrical wall 24 of the support snugly receives the end of the cylindrical portion 14 of the housing, from the upstream end thereof to a point just short of the circumferential openings 14a. Thereafter, a radial clearance is provided about the cylindrical portion 14 extending somewhat upstream of the openings 14a where the wall 24 terminates, to provide an annular chamber opening into the main air stream region of the fan.

The downstream end of the motor 10 includes an axially extending shaft 30 to which

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is secured a propeller hub 32. The hub includes an end wall 34 and an axially extending, cylindrical side wall 36. A plurality of fan blades 39 extend radially from the side wall 36 and when rotated in the direction indicated in Figures 2 and 3, create a main air stream going from left to right as indicated by the arrows M in Figure 1. The hub 32 is secured to the shaft 30 by means of a mounting ring 33 riveted to the end wall and having a bore to receive the end of the shaft. A set screw or other suitable means is employed to lock the hub to the shaft.

The end wall 34 of the hub is also provided with openings 38 (see Figure 3) to permit air to flow from the exterior of the fan into openings 18a in the downstream end of the motor housing 12. As indicated in the drawings, the radially extending sides of the openings 38 may be beveled in a direction consistent with the direction of rotation of the hub to facilitate the passage of air through the openings and into the motor housing.

The interior surface of the side wall 36 makes a running fit with the cylindrical portion 14 of the housing, that is, while permitting free rotation, it prevents substantial air flow between the parts. Thus, the cooling air is constrained to flow into the openings in the end face 18.

The running fit extends along the housing from its downstream end to a point short of the openings 14b. Thereafter, an increased radial clearance is provided to allow ready egress of air from the openings 14b into the main air stream.

The foregoing fan structure is shown mounted within a tubular duct or venturi 40. In the example illustrated, the duct 40 is formed integrally with a pair of rectangular frame members 42 and connected to the support 20 by struts 44 (see Figure 2). As seen in Figure 1, the latter is riveted to the frame portions 42 such as by rivets 46. One of the struts 44 may also be formed with an internal passage to conduct the electrical leads (not shown) from the motor.

In operation, as the propeller blades 39 are rotated by the motor 10, a main air stream M is created in the annular region between the exterior of the motor and the duct 40. As the flow is restricted, such as by the obstruction afforded by the apparatus that the fan is intended to cool, the pressure at the outlet, P_4 , increases. With the increased pressure, an increased load is imposed upon the motor with the consequent increase in internal motor heat.

Under free flow, or minimal outlet pressure operation, air flow M flowing over the wall 24 of the support 20 creates a low pressure P_2 at its upstream end by virtue of the venturi effect. This induces a pressure difference between P_1 and P_2 , thereby creating a cooling

flow through the upstream end of the motor via the apertures 28 in the support, the openings 16a in the upstream end face of the motor housing and out of the circumferential openings 14a into the main air stream. At the same time, the fan inlet pressure P_3 at the upstream edge of the fan blades will be less than the outlet pressure P_4 . Thus, there will be a flow of cooling air over the downstream end of the motor via the aperture 38 in the propeller hub, the openings 18a in the downstream end face of the motor housing and out of the circumferential openings 14b into the main air stream. Through these means, both ends of the motor are cooled using the pressure gradients existing within the flow stream.

As the flow of the main air stream becomes restricted, such as by working into an increased pressure region, the pressure at P_2 and P_3 increases, approaching that at the inlet P_1 . This tends to reduce the cooling air flow through the upstream end of the motor. At the same time, however, the pressure at P_4 increases at a greater rate than P_3 . The resultant high pressure difference between P_4 and P_3 increases the cooling flow at the outlet end of the motor. In addition, the higher pressure at P_4 induces a cooling flow through substantially the entire housing to the openings 14a at the upstream end of the cylindrical portion of the housing. The loss in cooling at the inlet end of the motor is thereby supplemented by the counter flow from the outlet end of the fan.

It will be recognized from the various pressure relationships resulting from operation of the fan that as the motor load increases, the pressure at P_4 and the flow of cooling air through the motor increases, with the result that a relatively constant motor temperature is maintained automatically over the complete range of operation of the fan.

As will be seen from the foregoing, the present invention provides for efficient cooling of a fan motor employing the natural air flows and pressure gradients established by the normal operation of the fan, without the addition of special air moving elements to create the necessary air flow. Moreover, the respective ends of the fan are independently cooled by cooling air flowing in opposite directions. Therefore, large pressure drops across the motor are avoided. All of the foregoing is achieved by means of a simple, inexpensive fan construction which lends itself to use in fans designed to occupy minimal space and operate at high efficiencies.

WHAT WE CLAIM IS:—

1. A self-cooled motor-driven fan comprising an electric motor enclosed in a housing, an air moving element driven by the motor to produce a main air stream axially of the motor, openings in the motor housing at each of its upstream and downstream ends, and

means responsive to the main air stream to establish motor cooling air flows from each end of the fan through the openings at the two ends of the motor housing and back into the main air stream.

5 2. A fan according to claim 1, in which the housing includes a cylindrical portion and a pair of end faces, and the openings are provided in both of the end faces and in the
10 cylindrical portion at circumferentially spaced places adjacent to each of the end faces, whereby the cooling air may flow in through the openings in the end faces and out of the
15 circumferential openings in the cylindrical portion.

3. A fan according to claim 2, in which one end of the motor housing is secured in a cup-shaped support which includes a base portion spaced from the adjacent end face of the housing and provided with at least one aperture to permit air flow to the openings in the end face, and an axially extending wall portion surrounding a part of the cylindrical portion of the housing adjacent to the said
20 one end, the wall portion being radially spaced from the cylindrical portion opposite the circumferential openings therein adjacent to the said one end, to provide an annular gap surrounding the circumferential openings to
25 enable air flow from the openings into the main air stream.

4. A fan according to claim 3, in which the motor includes a shaft extending through the end face at the other end of the housing
35 and the air moving element comprises a plurality of blades mounted on a hub having both an end wall adapted to be secured to the shaft and spaced from the associated end face

of the housing, and an axially extending side wall surrounding a part of the cylindrical portion of the housing and extending beyond the circumferential openings therein adjacent to the said other end, the side wall being radially spaced from the cylindrical portion of the housing over the full axial extent of the side wall.

5. A fan according to claim 4 in which the end wall of the hub is provided with at least one aperture permitting air flow to the openings in the associated end face of the housing.

6. A fan according to claim 4 or claim 5, in which the radial spacing of the side wall from the cylindrical portion of the housing between the other end of the housing end the adjacent circumferential openings is sufficient only to permit relative rotation therebetween but is greater over the remaining length of the side wall, to enable air flow out of the adjacent circumferentially spaced openings in the cylindrical portion to enter the main air stream.

7. A fan according to any one of claims 4 to 6, further comprising a member defining a generally cylindrical channel for the main air stream, the member surrounding the blades and maintained substantially concentric with the motor shaft by means extending from the support.

8. A fan according to claim 1, substantially as described with reference to the accompanying drawings.

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COMPLETE SPECIFICATION

1 SHEET

This drawing is a reproduction of
the Original on a reduced scale

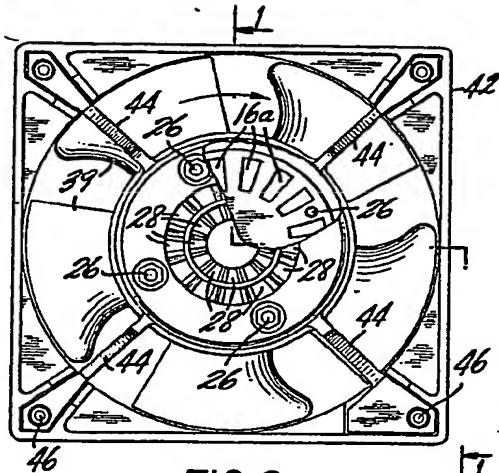


FIG. 2

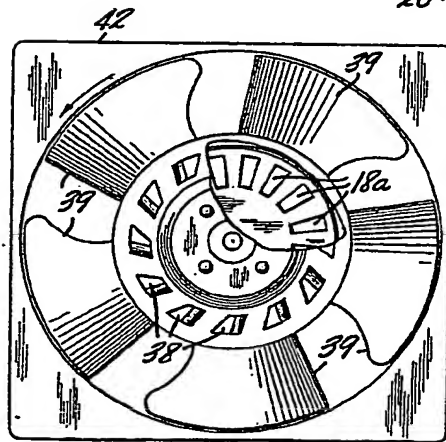
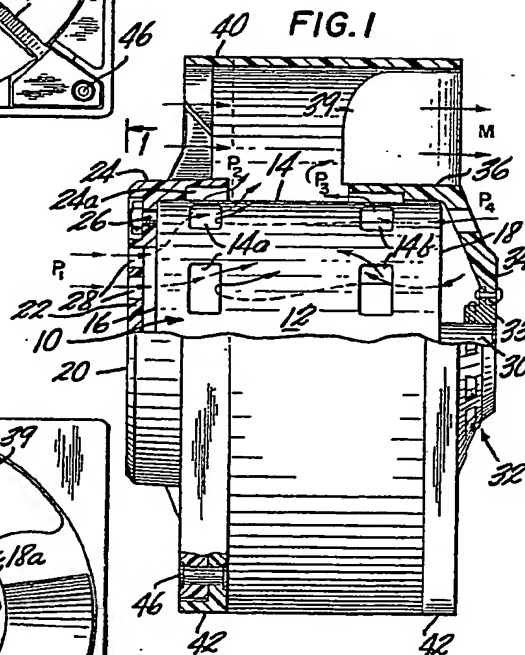


FIG. 3



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